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ABSTRACT

The demand for decision-support systems (DSSs) at the University of Hartford and the use of current software systems based on an information center approach are discussed. It is noted that declining enrollment demand and financial stress in tuition and enrollment-dependent universities requires a flexible and dynamic DSS for effective planning and management. The concepts of DSSs and the information center are reviewed, along with the characteristics of fourth-generation software systems. Contrasts are made between application-development strategies employed at the University of Hartford for on-line transaction processing and for decision support. Attention is directed to database management on the IBM mainframe. Applications that were designed and implemented by the Office of Planning and Institutional Research using fourth-generation systems software are discussed. The system of application development for decision support is described as a user-friendly structure of menus and screens that enables users to create and maintain a database and generate reports without programming. Finally, goals and plans are outlined for the development of a more comprehensive DSS at the university in 1984-1985. (SW)

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A Fourth-Generation Approach to Decision Support In A Private University

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This paper was presented at the Twenty-Fourth Annual Forum of the Association for Institutional Research held at the Hyatt-Regency in Fort Worth, Texas, May 6-9, 1984. This paper was reviewed by the AIR Forum Publications Committee and was judged to be of high quality and of interest to others concerned with the research of higher education. It has therefore been selected to be included in the ERIC Collection of Forum papers.

Daniel R. Coleman, Chairman
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Advisory Committee

ABSTRACT

A Fourth-Generation Approach to Decision Support
In A Private University

Declining enrollment demand and financial stress in tuition and enrollment-dependent universities requires a flexible and dynamic Decision-Support System (DSS) for effective planning and management.

This paper reviews Decision-Support Systems and the Information Center as concepts and describes the characteristic features of fourth-generation software systems. Contrasts are made between application-development strategies employed at the University of Hartford for on-line transaction processing and for decision-support. The presentation describes applications the Office of Planning and Institutional Research has designed and implemented using fourth-generation systems software. Goals and plans are outlined for the development of a more comprehensive Decision-Support System at the University in 1984-85.

Institutional Need For Decision Support

Strategic decisions and effective management are going to be critical to the survival, growth and improvement of the University of Hartford over the next two decades.

Established as a private, comprehensive university only 25 years ago, the University has grown rapidly and has become an extremely complex institution for its size, about 4,000 full-time and 4,000 part-time students. Growth in the University's enrollment, academic programs, staffing, physical plant and annual operating budget has been accompanied by increasing diversity in its student clienteles, academic programs and administrative structures.

Having limited endowment and annual giving per student, the University has a concentrated dependence on enrollment income (i.e., tuition, fees, room, board), on government-sponsored student-aid programs and on the philanthropy of corporations and benefactors in the Greater-Hartford area.

The external environment in which the University operates has become increasingly turbulent and is likely to remain threatening for at least another decade. For example, there are the threats of a 30 percent decline in the 18 year-old population in the Northeast, reductions in federal and state student-aid programs, declining demand for liberal arts and teaching programs, increasing institutional competition for students, rising institutional costs and the high costs of delivering science and technology programs.

To increase institutional effectiveness in a rapidly changing

environment, within the constraints of available resources, the leadership of the University has to take calculated risks and to make strategic choices that are well informed by intuition, judgement and relevant information. Keller (1983, pp. 49-52)

Decision making at the University is extremely dynamic; within the past year decisions have been implemented to launch a $30 million Capital Campaign, to construct on-campus apartments for 1,000 more students, to build a new computer-administration building, to convert administrative computing to an integrated-on-line database and to seek Division I status in intercollegiate athletics.

The leadership of the University also has to make incremental decisions as it searches for ways to improve the quality of academic programs and campus life and to increase the efficiency and quality of administrative services. Moreover, it has to satisfy the Board of Regents' requirements for a balanced annual operating budget, while offering students and parents competitive institutional pricing and student-aid packages and assuring faculty and staff of adequate working conditions and compensation.

Demand for decision-support systems is building at the University as decision makers and constituents have become increasingly frustrated in their efforts to obtain the relevant, accurate and timely information they need to make critical decisions. Building an effective decision-support system is going to take time, effort and commitment; however the information-center concept and fourth-generation software systems already available have considerable potential for improving strategic planning and management effectiveness.

Concept of Decision Support

The concept of Decision-Support Systems (DSS) is better understood today then it was a few years ago. Keen (1982, pp. 17-21) Decision-Support Systems use interactive computing as tools to help executives and managers to gain access to the information they need to inform their own human intuition and judgement and to make more effective and timely organizational decisions. As a result, the high priority information requirements for decision-support systems are for strategic planning and management control, rather than for routine operational decisions. Requirements for a DSS have to reflect the way executives and managers think and the conditions under which they make decisions. Leadership and problem-solving styles vary; and intuition, qualitative judgements and scenarios, rather than rationality, quantitative data and detailed transactions, are usually the issues of concern in making critical decisions. Decision making frequently is ad hoc, fragmented, and exploratory; it involves having to deal real time with many unanticipated problems. Keen (1982); Denise (1983)

In a Decision-Support System it is the decision-maker, rather than the programmer-analyst, who controls the design requirements. On-line retrieval of information from the database is through interactive computing which is user-friendly, flexible and responsive to ad hoc requests for information, generation of alternative planning scenarios or preparation of analytical reports. A flexible computer language is required for rapid creation and modification of applications. Dialogue with the computer has to be user-friendly, employing the decision-makers concept, language and sense of the information problem that has to be solved. Keen and Wagner (1979); Lankau (1982)

Decision-support systems are necessarily built in an evolutionary and incremental way as the information requirements of decision makers change and as fourth-generation software systems improve. As DSS technology continues to improve rapidly, more and more requirements for a comprehensive, integrated, Decision-Support System are going to be satisfied: Briggs (1982); Briggs and Meader (1982)

1) User-friendly retrieval for inquiry and report generation from extracts of the operational database.

2) Model building tools used to ask "what if" questions and to assess the consequences of alternative strategic decisions.

3) Interfaces between report generation and statistical analysis packages necessary for ad hoc analysis and institutional research.

4) Efficient filing, communication and retrieval of executive summaries, planning outlines, statistical summaries and graphical displays on demand to authorized decision makers.

5) Information-center support distributed through education, consulting and software support to those staff members who are in the best position to offer direct decision support to the University's key executives. Briggs (1982); Briggs and Meader (1982)

Fourth Generation Systems Software

Many users are satisfying their own ad hoc information retrieval requests using fourth-generation systems software. Others are even developing their own administrative applications and Decision-Support Systems. Martin (1982); Goetz (1982)

Interactive application development using fourth-generation

software has also yielded gains of five-to-one or ten-to-one in programmer productivity over earlier technologies. Martin (1982)

The requirements and distinctive features of fourth-generation systems software are constantly changing. However the following paragraphs do offer a reasonable generic description of the software products available today. Briggs (1982); Briggs and Meader (1982); Goetz (1982, pp. 1-14); Martin (1982)

An active data dictionary is the heart of the fourth-generation approach to application development. It is flexible and general enough to define the status and relationships among all information management resources in the university including data files, transaction screens, reports and authorized users. The dictionary integrates the database management system with transaction screens, application programs, query languages and report generators.

Creation and modification of the database is quickly and easily performed with a minimum of impact on application programs. Screen creation and management facilities provide for easy layout of screen formats in a prototype environment where the user and the programmer can work interactively to construct menus, screens and editing logic. Screen management facilities are easy to use and provide flexible access and rapid response time (i.e., three-to-five seconds) in requesting information.

Users of fourth-generation software systems view all data as simple tables consisting of rows and columns (i.e., a relational view of the database). How data are organized or stored, what relationships exist among data elements and programs are completely transparent to users.

Users retrieve and display information through interactive data

retrieval and reporting facilities using menus, screens or natural language commands to access the database.

Application-development tools and very high-level procedural or non-procedural languages greatly reduce the code that programmers have to create, debug and maintain. The level of technical expertise required to program, even complex applications, is considerably reduced with fourth-generation software.

Editors in fourth-generation software systems are easy to use and intelligent. They provide for easy insertion, deletion and manipulation of program statements, as well as detecting language syntax errors.

Fourth-generation software systems still lack the user-friendliness, functionality and level of integration necessary for decision makers to interact directly with the database. The critical linkage among mainframe, minicomputer and microcomputers required to assure free flow of programs and data through an information network is a problem vendors still have to solve. However it is possible to interface fourth-generation software systems to accelerate the development of administrative applications and Decision-Support Systems using an information center-approach. McNeish (1982); Keen (1982, pp. 20-21); Briggs (1982); Briggs and Meader (1982)

The Information Center

Although the concepts are relatively new, much has already been written about the Information Center and proto-typing, including case studies of successful implementations in both corporate and university environments. Whether decision support is centralized or distributed, the essence of the information center is cooperative development of applications and timely access to information using interactive

computing and prototypes as the means of communication among decision makers, decision-support staffs and information specialists. Alter (1980); Martin (1982); Hammond (1982); McCartney (1983); Baker (1982); Lewandowski (1984); Penrod and McManus (1982); Stevenson and Walleri (1983)

Clearly, decision makers know more about their own information requirements than do systems analysts or programmers. They have a better understanding of how reports and analyses should be structured to answer a question or to solve a problem. With user-friendly, information-retrieval software, decision makers can gain access to information quickly, analyze the results and adapt their search strategy to obtain more relevant and precise information. It is even practical for many users to develop their own applications without programming assistance. Martin (1982, pp. 298-310))

Information-center consultants encourage users to employ fourth-generation software to develop their own applications without programming. They work directly with end-users to build and modify prototypes and to specify changes necessary to convert prototypes into operational applications. Consultants are aware of what information already exists in the database and what user-friendly software is available to satisfy information requests. Martin (1982)

Prototyping is especially useful in satisfying ad hoc reporting requirements, where an application is needed immediately or where there is uncertainty about the feasibility, design, cost or utility of an application. Design and development of prototype applications is incremental and evolutionary. Experience gained in early testing is used to refine requirements and to make further modifications. Better applications can be developed more quickly using this prototyping

approach. Depending on the complexity of the application, accessibility of data and availability of software tools, prototype applications may take a few hours, a week or a few months to implement. Asner and King (1981); Keen (1982); McCartney (1983); Lankau (1982)

Effective cooperation and coordination of decision-support efforts is essential to avoid unnecessary duplication of effort and divisive role conflict in offering information-center services. Martin (1982, p. 307) Formal organizational structures should be designed to take maximum advantage of the knowledge and expertise of the database administrator, planning and institutional research staff, computer-services staff and administrative-support staff of key decision makers. Support for the information center will build as users learn to make effective use of available software tools and information consultants and as they gain increasing expertise in satisfying their own information requirements.

Database Management On The IBM Mainframe

The University of Hartford is making a substantial investment to increase the efficiency and quality of its administrative computing operations. Following a review of vendor proposals by an ad hoc task force, Systems and Computer Technology Corporation (SCT), the leading vendor of administrative-applications software in higher education, was selected as the successful contractor. The University will be one of the first institutions to install all three of SCT's on-line database systems as integrated applications for student records, human resources and financial management.

SCT's application-development strategy uses a top-down design approach which permits systems to be defined, validated and debugged

in modules. During the specifications phase, SCT consultants work with user task forces using documentation from their baseline systems as the means to identify necessary changes in data dictionaries, data-entry screens and batch reports.

The SCT application systems are implemented using COBOL as the host language and the IBM Customer Information Control System(CICS) and CINCOM's TOTAL as the database management system. Clerical staff find the screens easy to use; and the system is extremely efficient in processing transactions or retrieving individual records for students, courses, faculty, staff and funds.

Unfortunately, from the decision-support perspective, SCT applications are implemented using the third-generation software products of CINCOM. The batch reports SCT provides with the system are all programmed in COBOL. Extracts, selection criteria, sorting and the format of reports are all predefined and prescribed. Socrates, the report generator offered with CINCOM's third-generation software is powerful in navigating the database; however it is designed for programmer-analysts rather than for administrative users.

The SCT application-development strategy uses COBOL program-generation techniques. Data descriptions for COBOL programs are copied from a passive data dictionary stored in a source library. Facilities for defining and creating screens are implemented using CICS/TOTAL commands and structured programming with a COBOL generator SCT has developed.

With CINCOM's fourth-generation software, users and programmer analysts can prototype screens and make changes in the data directory together through on-line interactive computing. Query and report-generation facilities are also integrated with the data

dictionary to provide user-friendly access to information from extracts of the database. CINCOM (1983)

Through a cooperative extended-license agreement, SCT has developed a menu-driven system for downloading extract data files from the IBM mainframe to the IBM PC. Assuming that the extracts are well designed, users may be able to satisfy their reporting requirements using fourth-generation software products available on the IBM PC.

At this point the University has three basic choices for satisfying its information requirements for decision-support from the database:

1) Invest in CINCOM's fourth-generation software system (TIS), converting to a more flexible and responsive application-development strategy.

2) Acquire a user-friendly query and report-generator facility: e.g., EASYTRIEVE or T-ASK for use with SPSS or SAS statistical-analysis packages on the IBM mainframe.

3) Review the design of extracts from the database and make the system for retrieving and downloading extracts to the IBM PC more flexible.

Application Development for Decision Support

Planning and Institutional Research has designed and programmed a system of application development for decision support (ADDS). It is a user-friendly structure of menus and screens, which enables users to create and maintain a database and to generate reports without programming. Using ADDS in an interactive computing environment, information consultants can

help users to satisfy their own information requirements rapidly in a variety of application-development situations:

1. Generate reports from data downloaded to the IBM PC from database extract files stored on the IBM mainframe computer.
2. Integrate multiple database files on the IBM PC to extract data for ad hoc reporting, model building or statistical analysis.
3. Through a distributed database have users generate reports that satisfy their own information requirements without assistance from application programmers.
4. To prototype administrative-computing applications with users before investing in time-consuming and costly development of integrated applications on the mainframe computer.

ADDS is written in D-BASE II, a powerful procedural-programming and interactive-query language. ADDS menus and screens are designed for simplicity, ease of use and efficiency in application development. D-BASE II has the power to implement even complex applications, using ADDS for the basic system, then adding D-BASE II program modules for editing logic, computations and systems tables. PC Magazine (1984)

A D-BASE II data directory is created for each database file amd report-file users want. The file structure defines each field in a record indicating the name, type, length, and decimal position for each data field. Having created the directory, users only have to refer to the names of data fields in processing their ADDS information requests. If their

information requirements change, file structures and data-field characteristics are easily modified even after the data bases have been created.

D-BASE II data-entry screens are programmed entering headings and the names of data fields in row and column locations on a screen that has 24 rows and 80 columns. Users without programming experience can learn how to program data-entry screens immediately following a brief tutorial. This process is further simplified through the ADDS screen generator which only asks the user to enter the names of the data fields in a five-row, six-column format. Grid headings are then automatically displayed in this format when records are accessed from the data base.

Having created a data directory and data-entry screen for each file in the database, the next step is to link the screens and files together through the ADDS screen/file management programs. The user only has to specify which data fields he wants to use as primary search keys for locating records in each data file (e.g., name, social security number, position number, account number). At the time of data entry users specify their strategy for searching records using the ADDS screen/file management menu. Choices include accessing multiple screens for each record or processing multiple records using the same screen.

ADDS has a procedure for rapid keying of transactions for any data file in the screen/file management system. The ADDS transaction-processing program automatically accesses records in whatever sequence the user wants; displaying

identification data fields and skipping to the next record or data field automatically as each data element is keyed. The user can either request an error log to validate and correct transactions or update transactions directly to the data file without editing.

Selection criteria are entered using English-like statements of logical conditions for including records in reports. Data fields, logic, data values and connectors are expressed as in the following example:

School = 1 and Tenure = T and Sex = F.

To specify the sequence for extracting or reporting records, the user merely enters the names of the data fields for the sort key listed from the major to the minor field; i.e., school, tenure, rank, and sex would sort in sequence — sex within rank, within tenure, within school.

Users can also specify a page break or record break for printed listings, labels or tabulations at each level of the sorting sequence.

The ADDS report-extract program allows users to select and extract data fields from as many as four data files to create a report file that contains the required data fields. The user only has to specify the names of the data files, the index for sequencing records and the names of the data fields to extract.

The ADDS view/display screen enables the user to maintain archive files for multiple years and multiple data segments for each record. The user specifies the name of the transaction file and the name of the archive file to be

updated. If he wants to add new records, for example, for a particular year, he merely has to enter the name of the data field, academic year, and the range of years for which new records are to be added. The same procedure is used to delete old records from an archive file.

The user can specify up to four secondary indexes used as search keys to point to the beginning of a file of selected records and to sequence those records in accordance with that index for visual display. If, for example, school were included as an index, the user would only have to enter the value that corresponds to the selected school; e.g., 2 = College of Arts and Sciences, and the visual display would point to the beginning of those records. The user can then browse through those records in whatever sequence he has requested. As many as six user-specified data fields may be requested in a single visual display in a matrix of six data columns and twenty data rows.

With the ADDS report-listing program the user controls which data fields are to be printed and indicates where those data fields are to be displayed in a three-line, two-line or one-line roster format.

The ADDS program for printing labels is especially useful for direct mail and survey research applications. The select and sort features enable the user to produce labels only for records that satisfy his selection criteria and to print the labels in whatever order is necessary for processing or mailing. The names of data fields and mailing tags and their locations on the label are specified by the user in a six-row,

three-column format.

In preparing frequency distributions, sums and averages, users have considerable flexibility. Selection criteria can be used to select only those records the user wants to include in the summary. Page breaks indicated in specifying the sort sequence reinitialize frequency distributions, sums and averages each time a page break occurs. The user can specify any numerical data field in any data file as the field to be used in frequency distributions, sums and averages. Summary data are retrieved rapidly from indexed files in either view screen or printed format.

Because ADDS is written in D-Base II, any logic, computation, editing or other functions that require programming can be linked into the ADDS screen/file management and report generation systems. This approach supports structured design and programming methodologies; it permits easy modification and enhancement of existing applications without having to change the screen/file management or report generation programs.

Enrollment/Financial Planning Model

An enrollment/financial planning model, has been used extensively in strategic planning and budget forecasting during this past year at the University. Alternative scenarios for the next five years were modeled with executive summaries reviewed by the President and senior officers, the Executive Committee and Financial Committee of the Board and an Ad Hoc Budget Advisory Team appointed by the President.

Alternative scenarios for enrollment forecasts,

institutional pricing, student aid, staffing and compensation were reviewed by the Ad Hoc Budget Advisory Team using the model to assess the impact of each scenario on the annual operating budget. Recommendations from the Budget Advisory Team were submitted to the President for review and decision after consultation with the appropriate committees within the Board of Regents.

Planning and Institutional Research developed the Enrollment/Financial Planning Model using a new fourth-generation software product, Lotus 1-2-3. Today Lotus 1-2-3 represents the state-of-the-art in integrated software for worksheet processing, graphics and file management. Its power, speed and flexibility in combining functions greatly expands the power of the IBM personal computer for model building. McIntire (1983)

The Enrollment/Financial Planning Model consists of an Executive Summary and eight integrated model components: 1.enrollment forecasting, 2.credit hours, 3.institutional pricing, 4.income, 5.financial-aid, 6.higher-education prices, 7.administrative positions/salaries, 8.faculty positions/ salaries.

Columns of the model provide a five-year history of data trends, data for the current year and forecasts based on user-specified assumptions and policies for the next five years. Annual percentage changes and indexes to a baseline year (FY 1979-80) are computed for key indicators in the model. Any index or data lines in the model can be graphed interactively to produce trend lines, bar graphs or pie charts.

An Executive Summary was prepared through prototyping; key decision makers identified the key strategic variables and selected the rows and columns of the model that they felt were most important. The Executive Summary is integrated with the other model components so that changes taking place in any of the eight detailed models are simultaneously taking place in the Executive Summary.

The enrollment forecasting model has an index which provides the annual percentage change in high-school graduates from 1979 through 1988-89, assuming 15%, 25% and 40% declines in the number of high-school graduates. A student-flow model monitors historical trends and allows separate forecasts of applications, acceptances and admissions yield for freshmen and transfers. Historical trends for spring-to-fall and fall-to-spring carryover for returning students are used with new student estimates to forecast full-time undergraduate enrollments.

Full-time credit hours generated for undergraduate and graduate students are computed directly from the enrollment forecasting model. Historical trends in part-time credit hours for undergraduates and graduates are provided with annual percentage changes used as the basis for forecasting part-time credit hours for the next five years.

Alternative institutional pricing strategies are assessed for their impact on tuition, fee and room-and-board income and on the size of the student-aid budget necessary to satisfy the need of financial-aid recipients.

The income model displays the results of enrollment and

student credit-hour forecasts in combination with alternative institutional pricing strategies. Historical trends in the ratio of gross-tuition income to net-tuition income are taken into account after course withdrawals and tuition credits are considered. Individual forecasts are made on an annual percentage change basis for other categories of income, such as endowment, unrestricted gifts, short-term investments and conferences income.

Enrollment forecasts for new and returning students are combined with the percentage of students offered financial aid and student budgets to generate the gross family costs of attendance for financial-aid recipients. When the university's student-aid funds are combined with external student-aid funds, the average financial-need gap per family and the average financial-aid award are computed. The ratio of university funds to total aid funds and the ratio of university aid to net-tuition income are examined to determine the extent of tuition discounting.

The consumer-price index and higher-education price indexes are provided to monitor external salary trends for faculty and staff by job classification. Similarly, external norms are available for average faculty salaries for IIA institutions by academic rank.

The salary/position control model analyzes historical trends in the number of positions, average salaries, and total salary expenditures by academic rank or job classification; i.e., executive, administrative, professional administrative, secretarial, clerical, crafts and technical part-time

positions. Position and salary increments can be modeled across all classifications of positions or for specific classifications to forecast total salary expenditures. Indexes are provided for comparing changes in average salaries at the University with the higher-education price indexes for salaries by academic rank or job classification.

Decision-Support: Goals for 1988-89

The Office of Planning and Institutional Research plans to continue ADDS development and information-center support for applications implemented this year: a faculty information system, staff salary and position control, and an enrollment-management database. ADDS is currently being considered for an alumni-development system.

Enrollment-management databases for classes entering in 1979 and 1984 will be uploaded to the DECVAX 11/780 where SPSSx multivariate-analysis studies will be performed for studying admissions yield, student retention and financial aid in each college of the University.

Interfaces will be developed to use downloaded extract files from the IBM mainframe to the IBM PC where ADDS can be used as a decision-support tool or ad hoc reporting and analysis.

Using the file management capabilities of IBM DOS, DBASE-II, LOTUS 1-2-3 and Multi-Edit, a prototype information-management system will be developed to exchange strategic planning and management information among the leadership of the University using the IBM PC as an executive/professional work station.

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